Implementing OSD Systems Engineering Policy

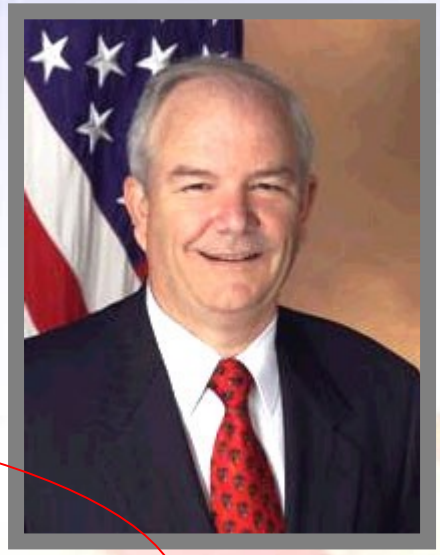
November 5, 2004

Robert J. Skalamera

Deputy Director, Systems Engineering, Enterprise Development
Office of the Under Secretary of Defense (AT&L)

USD(AT&L) Imperatives

- “Provide a context within which DOD can make decisions about individual programs.”
- “Achieve credibility and effectiveness in the acquisition and logistics support processes.”
- “Help drive good systems engineering practice back into the way we do business.”



SE Education and Training Summit (October 2003)

- Brainstorming session
  - What's working
  - What needs to be fixed
  - Significant barriers
  - Required actions
- Participants
  - Services
  - Academia
  - Industry
  - Associations (NDIA, AIA, EIA, GEIA, INCOSE)
- Formed five working groups, assigned leads
  - Policy
  - Processes
  - Tools and guides
  - Resources
  - Education and training

What We Found: Lack of Uniform Understanding of SE at Department Level

- Lack of coherent SE policy
- Lack of effective SE implementation - no “forcing function” for PM or contractor SE activities
- Program teams incentivized by cost and schedule, not execution of disciplined SE
- Products and processes not in balance (emphasis on speed; fix it in the next spiral)
- Inconsistent focus across life cycle, particularly prior to Milestone B
- SE inadequately considered in program life cycle decisions

What We Found: Lack of Uniform Understanding of SE in Community-at-Large

- No single definition or agreement on the scope of SE
- Lack of common understanding of how SE is implemented on programs
  - Is SE done by the systems engineer?
  - Does the systems engineer lead the SE effort?
- No uniform understanding of what makes a good systems engineer
- No consistent set of metrics/measures to quantify the value of SE
- Cost and schedule estimation and risk management processes inconsistently aligned with SE processes
- Resistance to harmonization of multiple standards and models
- Multiple practitioner communities not aligned:
  - Hardware - Aircraft vs. Rocket Developers
  - Software - Telecommunications
  - Information Technology - Program Management

What We Found: System Complexity

- System complexity is ever increasing – Moore's Law at the system scale – Family of Systems/System of Systems interdependencies
- Integrated systems (software with embedded hardware) versus platforms (hardware with embedded software)
- Network centric, spiral development, and extension of system applications are driving higher levels of integration

What We Found: The Resource Picture

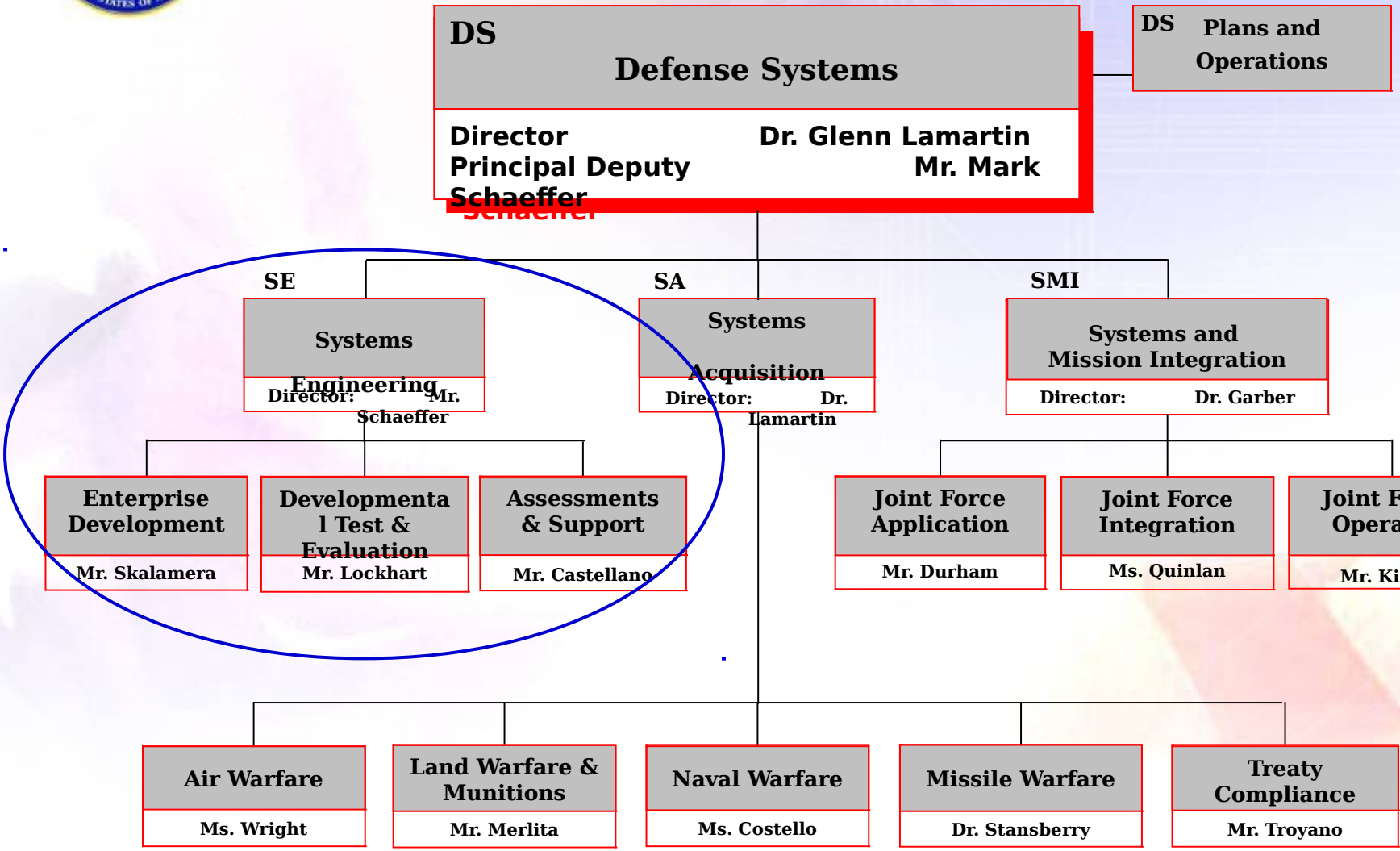
- Degreed workforce is a shrinking pool
  - Many graduates are not US citizens
  - Total engineering enrollments continue to decrease
- Ability to attract and retain young engineers in the aerospace industry is directly associated with the commercial marketplace
  - The aerospace and defense industry is seen as being overly bureaucratic and lacking in exciting technical challenges by engineering students
  - 5 year itch
- Existing university/industry partnerships are not having enough impact.
  - SE is not a standard discipline (EE, ChemE, ME, etc.)
  - More focus at undergraduate level
  - Do we have critical mass in terms of SE graduate level training in the U.S.?
- Need new ways to attract and develop system engineers
  - Additional learning
  - On-the-job experience

We need a better approach

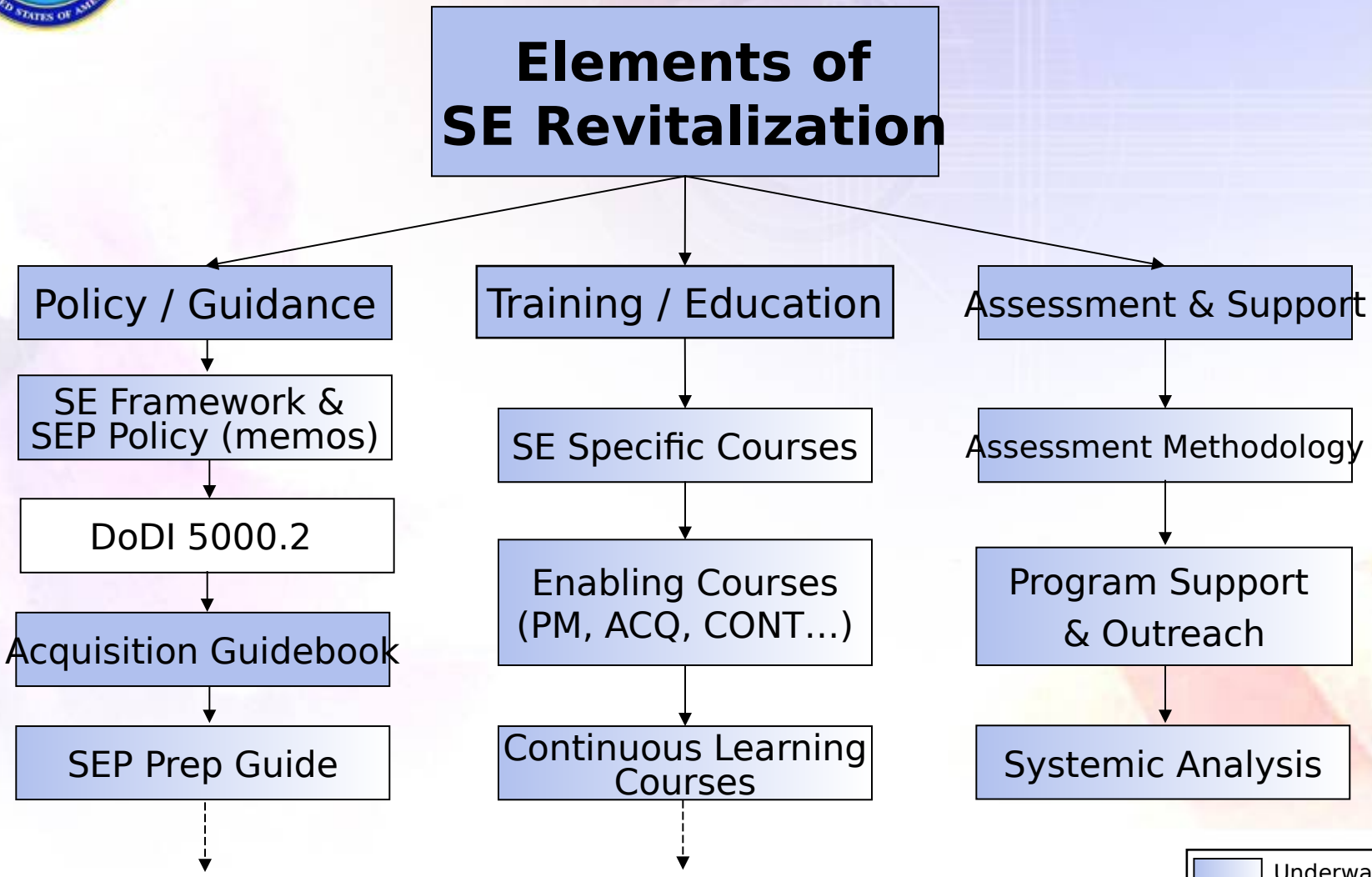
Adapted from G. Shelton (Raytheon

Systems Engineering Revitalization

Defense Systems Organization

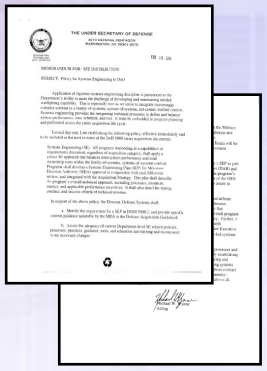


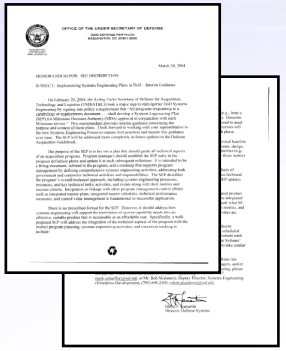
SE Revitalization

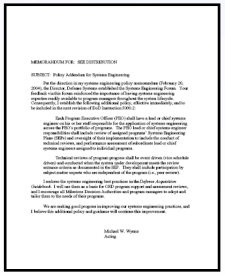


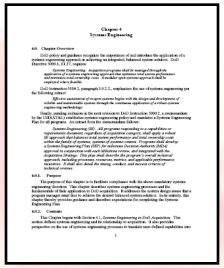
Policy and Guidance

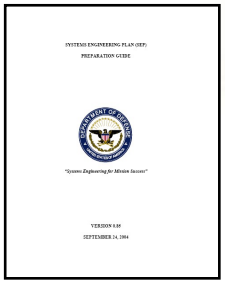
- DUSD(AT&L) SE Policy Memo
- Director, DS, SEP Interim Guidance Memo
- DUSD(AT&L) SE Policy Addendum
- Defense Acquisition Guidebook, Chapter 4
- SEP Preparation Guide











Systems Engineering Policy in DoD

Signed by the Honorable Mike Wynne, USD(AT&L) (Acting) Feb 20, 2004

- All programs, regardless of ACAT shall:
  - Apply an SE approach
  - Develop a Systems Engineering Plan (SEP)
    - Describe technical approach, including processes, resources, and metrics
    - Detail timing and conduct of SE technical reviews
- Director, DS tasked to provide SEP guidance for DoDI 5000.2
  - Recommend changes in Defense SE
  - Establish a senior-level SE forum
  - Assess SEP and program readiness to proceed before each DAB and other USD(AT&L)-led acquisition reviews

SEP Implementation Guidance

Per OUSD(AT&L) Defense Systems Memo signed Mar 30, 2004

- Submitted to MDA at each Milestone, SEP describes:
  - Systems engineering approach
    - Specific processes and their tailoring by phase
    - Both PMO and Contractor processes
  - Systems technical baseline approach
    - Use as control mechanism, including TPMs and metrics
  - Technical review criteria and outcomes
    - Event driven
    - Mechanism for assessing technical maturity and risk
  - Integration of SE with IPTs and schedules
    - Organization, tools, resources, staffing, metrics, mechanisms
    - Integrated schedules (e.g., IMP and IMS)

SE Policy Addendum

Signed by the Honorable Mike Wynne, USD(AT&L) (Acting)
Oct 22, 2004

- Each Program Executive Officer (PEO) shall have a lead or chief systems engineer
- The PEO lead or chief systems engineer shall:
  - Review assigned programs' SEPs and oversee their implementation
  - Assess the performance of subordinate lead or chief systems engineers
- Technical reviews shall:
  - Be event driven (vice schedule driven)
  - Conducted when the system under review meets review entrance criteria as documented in the SEP
  - Include participation by subject matter experts independent of the program, unless waived by SEP approval authority in the SEP

Technical Reviews Best Practice

Technical reviews:

- Are a fundamental part of the SE process and serve as a technical assessment product for the program manager
- Should be event based
  - Objective entry criteria need to be defined upfront
- Are only as good as who conducts them
  - Engagement of Technical Authority
  - Chair independent of program team
  - Independent subject matter experts, determined by
  - Involve ALL STAKEHOLDERS
- Should review entire program from a technical per
  - Cost, schedule, and performance
  - By ALL STAKEHOLDERS
  - Involve all technical products (specs, baselines, risks, cost estimates)
- Should result in program decisions and changes
  - Rather than a "check in the box"
- Taken as a whole series, form a major part (backbone) of the SEP

Easy in principle, Difficult in practice

Systems Engineering Plan

- Developed a SEP Preparation Guide (Vers 0.90)
- Resides on OSD/DS/SE page with links to appropriate guidance in *Defense Acquisition Guidebook*
- Will implement on select programs currently developing their SEP
- Will continue collecting feedback to revise and update Guide

http://www.acq.osd.mil/ds/se/publication

Importance and Criticality of the SEP

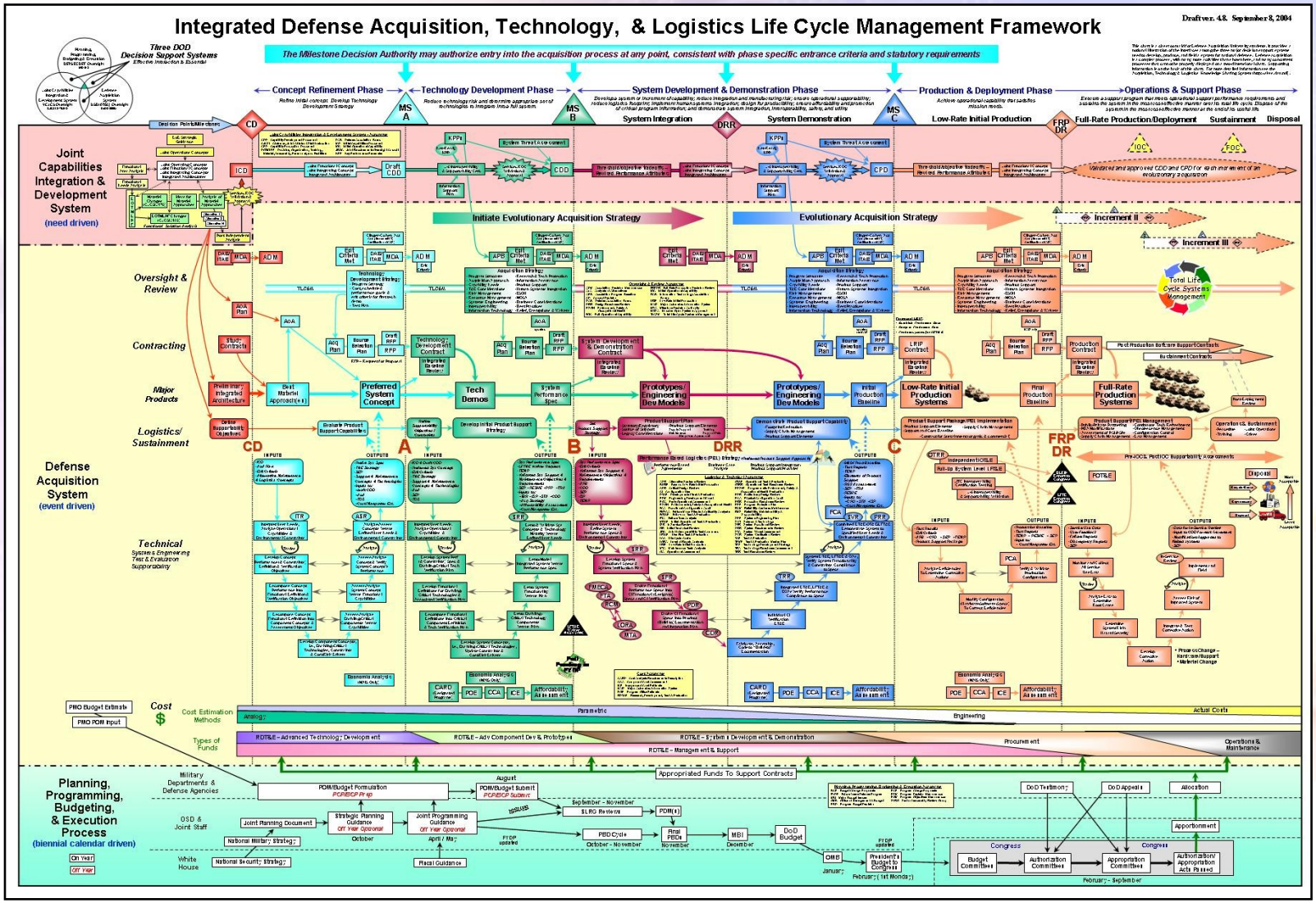
A program's SEP is envisioned as:

- THE primary mechanism for systems engineering revitalization
- Overarching, integrating technical plan for program's implementation of systems engineering best practice (and all that entails)
  - Primary means for collective insight to how the program will be technically managed: SE, T&E, Supportability
  - Scope and role of Technical Authority, process implementation, technical reviews, technical baseline management, technical risk assessment, independent peer review implementation, etc
- Primary mechanism to implement and effect best practice (*Defense Acquisition Guidebook*)
  - Does the program have the resources to plan and execute?
  - Are we prepared to address program issues (e.g. resource limitations) with "best practice?"
- A living document
  - Should contain evidence for use, application, and update

SE in *Defense Acquisition Guidebook*

- New SE guidance to acquisition community—Chapter 4
- Best practices for “applied” SE
  - SE process
  - Guide for each acquisition phase, concept refinement through disposal
- Linkage of SE products and processes to acquisition objectives and decision points

SE in the System Life Cycle "The Wall Chart"



SE in the *Defense Acquisition Guidebook*

4.1 SE in DoD Acquisition

4.2 SE Processes: How SE is Implemented

4.3 SE in the System Life Cycle

4.4 SE Decisions: Important Design Considerations

4.5 SE Execution: Key SE Tools and Techniques

4.6 SE Resources

SE in *Defense Acquisition Guidebook* Chapter 4, Section 4.1

- What systems engineering is
- Who does SE and how its integrated in a program management office
- It’s role across the total life cycle of a system and in evolutionary acquisition
- The relationship of SE to the IPPD framework
- SE leadership: role of the lead/chief systems engineer

SE Processes: How SE is Implemented
Defense Acquisition Guidebook
Chapter 4, Section 4.2

- SE terminology, models, and standards
  - Technical Management Processes

• Decision Analysis • Technical Planning • Technical Assessment • Requirements Mgmt	• Risk Management • Configuration Mgmt • Technical Data Mgmt • Interface Management

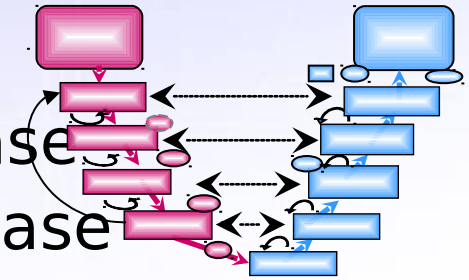
  - Technical Processes

• Requirements Development • Logical Analysis • Design Solution • Implementation	• Integration • Verification • Validation • Transition

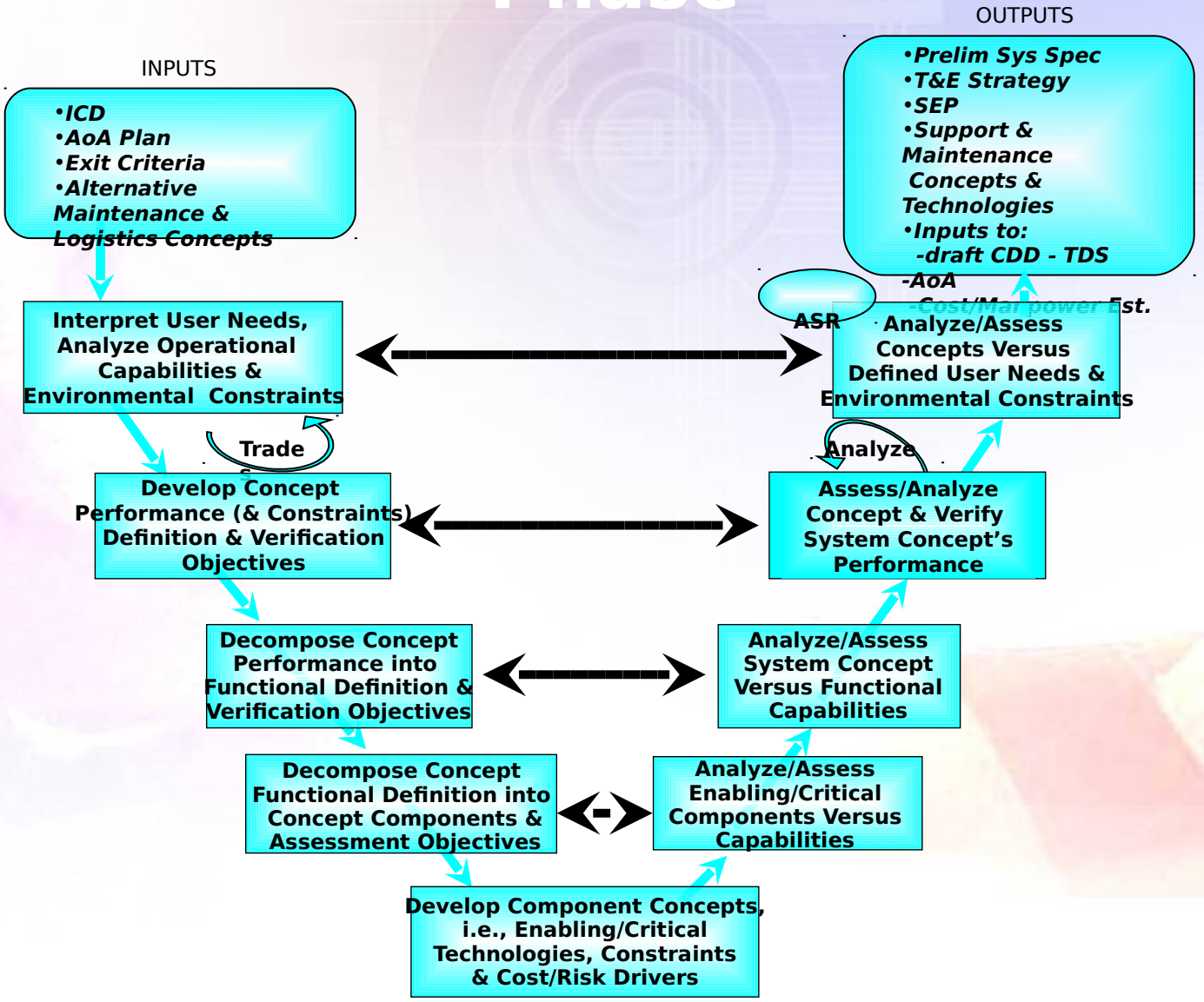
- Contractor capability maturity in context:
  - Process maturity
  - Domain expertise
  - Dispersed team (corporate & geographic boundaries)
  - Just-in-time assessment (past, current, or future team)

SE in the System Life Cycle
Defense Acquisition Guidebook
Chapter 4, Section 4.3

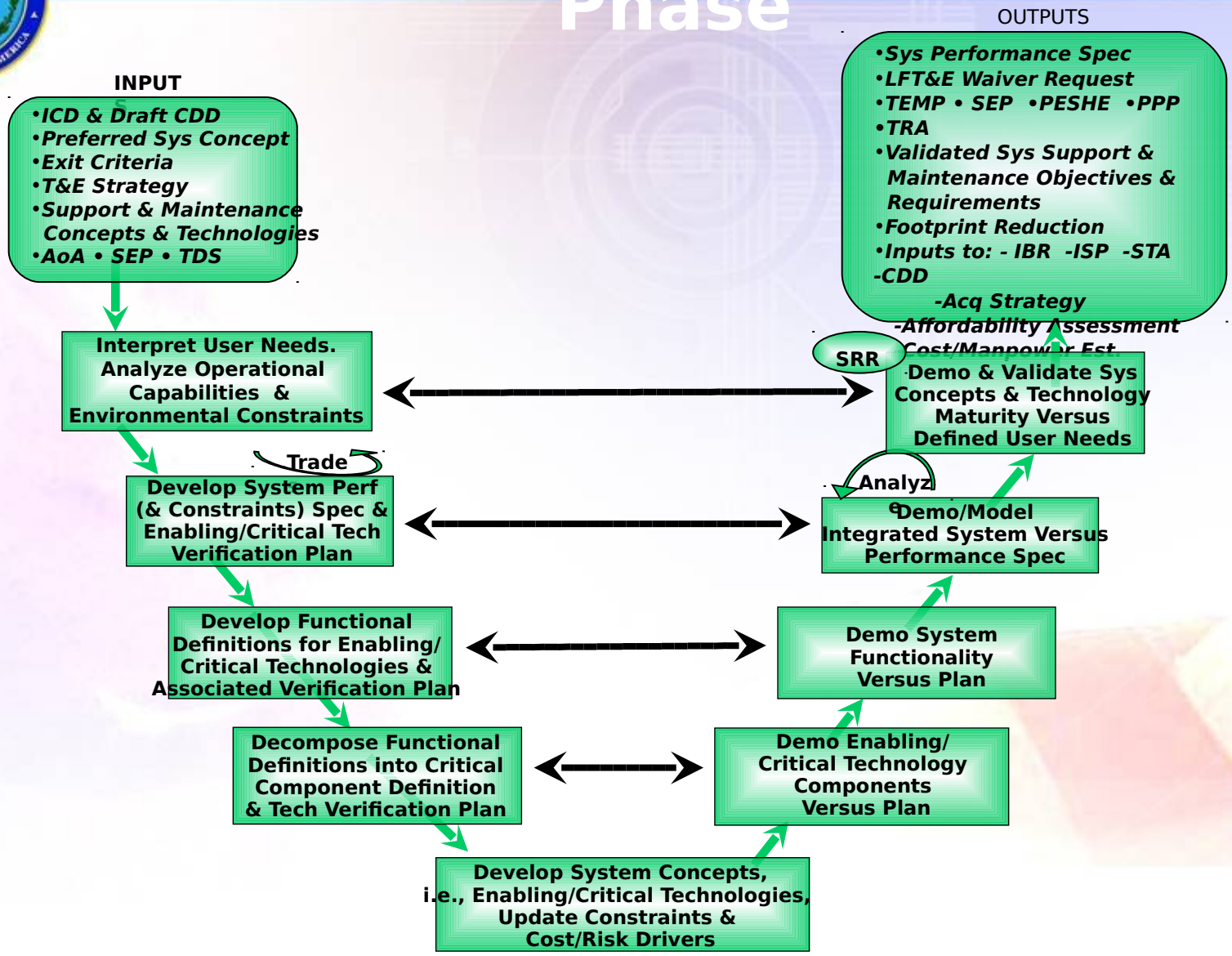
- By phase consideration of SE activities
  - Purpose of SE in the phase
  - Inputs to the SE process
  - Key SE activities during the phase
  - Technical reviews during the phase
  - Outputs of the phase's SE process
- Full life cycle coverage from Concept Refinement through Operations and Support



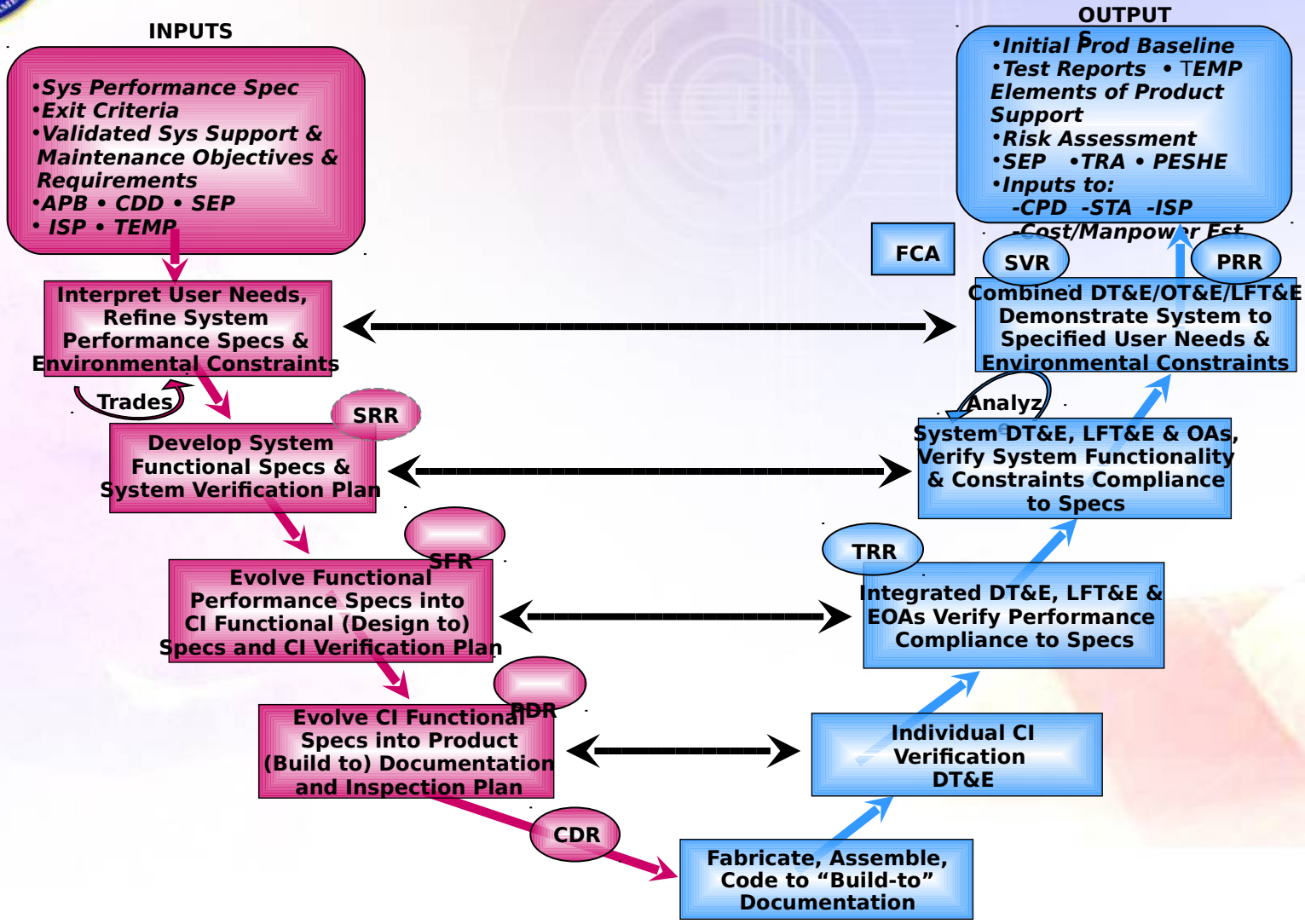
Concept Refinement Phase


INPUTS
•ICD
•AoA Plan
•Exit Criteria
•Alternative Maintenance & Logistics Concepts
OUTPUTS
•Prelim Sys Spec
•T&E Strategy
•SEP
•Support & Maintenance Concepts & Technologies
•Inputs to:
-draft CDD - TDS
-AoA
-Cost/Man power Est.
Interpret User Needs, Analyze Operational Capabilities & Environmental Constraints
ASR
Analyze/Assess Concepts Versus Defined User Needs & Environmental Constraints
Trade
Analyze
Develop Concept Performance (& Constraints) Definition & Verification Objectives
Assess/Analyze Concept & Verify System Concept's Performance
Decompose Concept Performance into Functional Definition & Verification Objectives
Analyze/Assess System Concept Versus Functional Capabilities
Decompose Concept Functional Definition into Concept Components & Assessment Objectives
Analyze/Assess Enabling/Critical Components Versus Capabilities
Develop Component Concepts, i.e., Enabling/Critical Technologies, Constraints & Cost/Risk Drivers

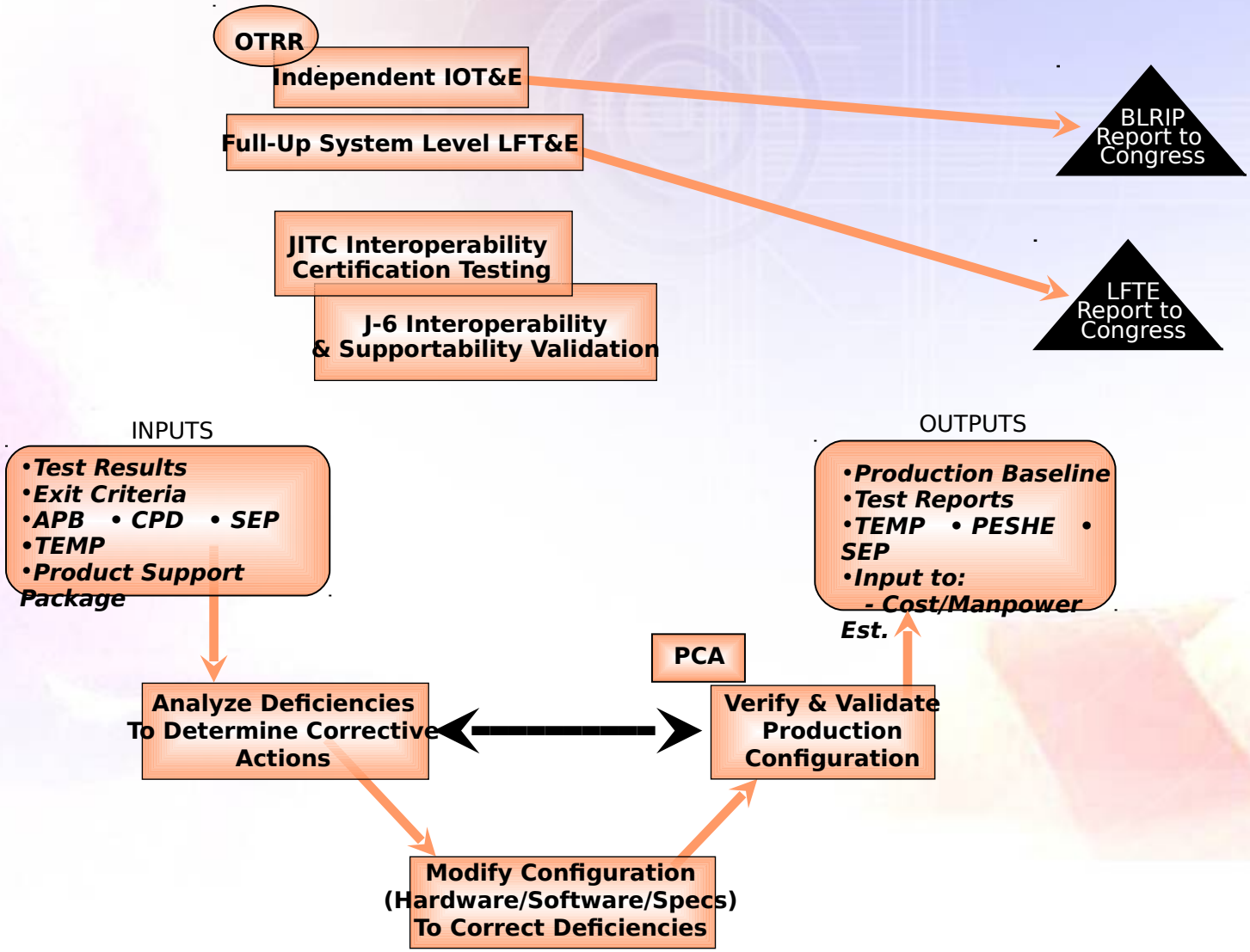
Technology Development Phase


INPUT
•ICD & Draft CDD
•Preferred Sys Concept
•Exit Criteria
•T&E Strategy
•Support & Maintenance Concepts & Technologies
•AoA • SEP • TDS
OUTPUTS
•Sys Performance Spec
•LFT&E Waiver Request
•TEMP • SEP •PESHE •PPP
•TRA
•Validated Sys Support & Maintenance Objectives & Requirements
•Footprint Reduction
•Inputs to: - IBR -ISP -STA -CDD
-Acq Strategy
-Affordability Assessment
Interpret User Needs. Analyze Operational Capabilities & Environmental Constraints
SRR
Demo & Validate Sys Concepts & Technology Maturity Versus Defined User Needs
Trade
Develop System Perf (& Constraints) Spec & Enabling/Critical Tech Verification Plan
Analyze
Demo/Model Integrated System Versus Performance Spec
Develop Functional Definitions for Enabling/ Critical Technologies & Associated Verification Plan
Demo System Functionality Versus Plan
Decompose Functional Definitions into Critical Component Definition & Tech Verification Plan
Demo Enabling/ Critical Technology Components Versus Plan
Develop System Concepts, i.e., Enabling/Critical Technologies, Update Constraints & Cost/Risk Drivers

System Development and Demonstration Phase


INPUTS
•Sys Performance Spec
•Exit Criteria
•Validated Sys Support & Maintenance Objectives & Requirements
•APB • CDD • SEP
• ISP • TEMP
OUTPUTS
•Initial Prod Baseline
•Test Reports • TEMP
Elements of Product Support
•Risk Assessment
•SEP •TRA • PESHE
•Inputs to:
-CPD -STA -ISP
-Cost/Manpower Est
FCA
SVR
PRR
Interpret User Needs, Refine System Performance Specs & Environmental Constraints
Trades
Combined DT&E/OT&E/LFT&E Demonstrate System to Specified User Needs & Environmental Constraints
SRR
Develop System Functional Specs & System Verification Plan
Analyze
System DT&E, LFT&E & OAs, Verify System Functionality & Constraints Compliance to Specs
SFR
Evolve Functional Performance Specs into CI Functional (Design to) Specs and CI Verification Plan
TRR
Integrated DT&E, LFT&E & EOAs Verify Performance Compliance to Specs
PDR
Evolve CI Functional Specs into Product (Build to) Documentation and Inspection Plan
Individual CI Verification DT&E
CDR
Fabricate, Assemble, Code to "Build-to" Documentation

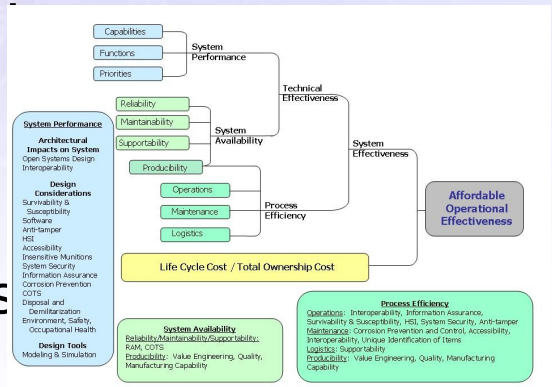
Production and Deployment Phase



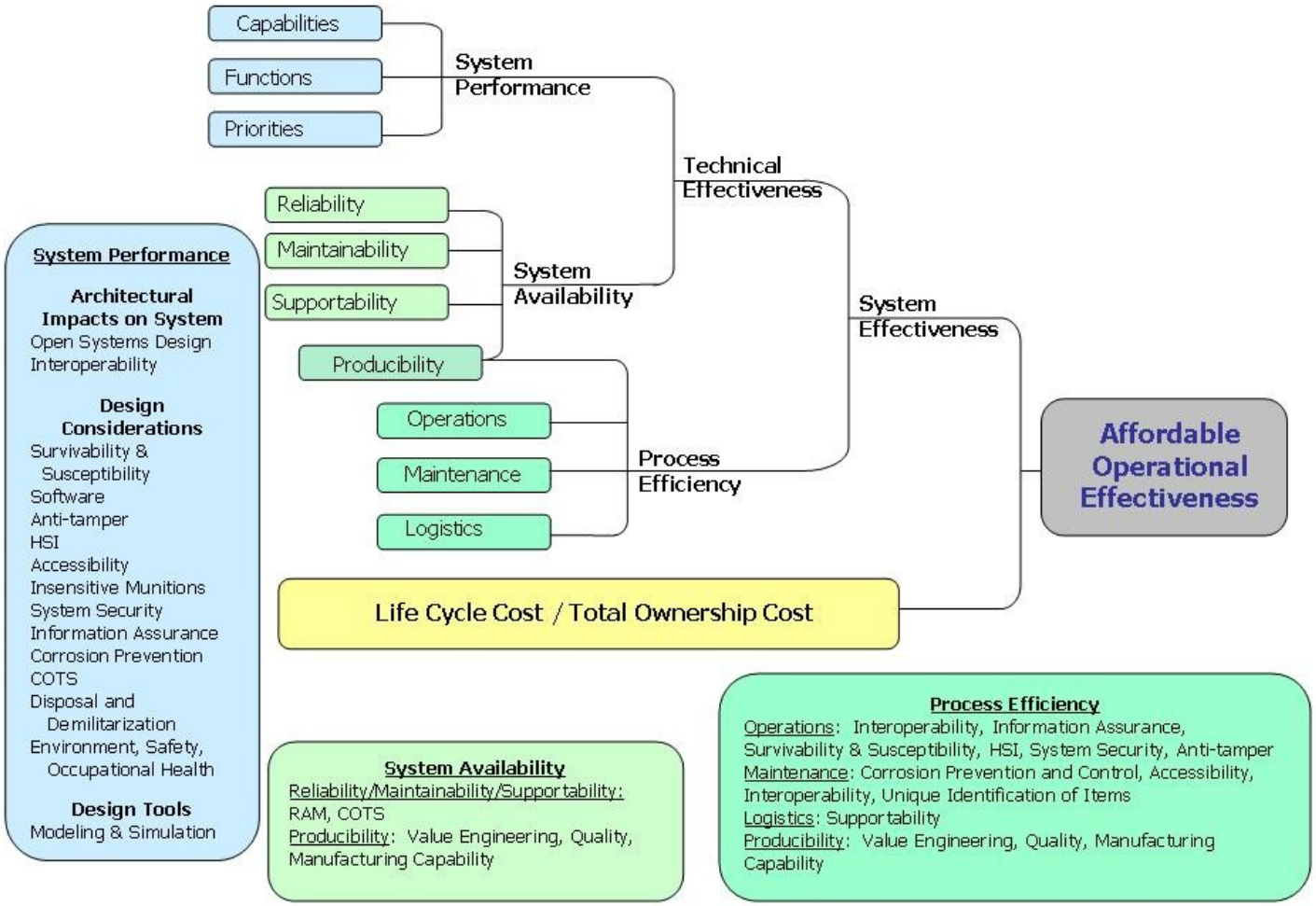
Operations and Support Phase

SE Decisions: Important Design Considerations
Defense Acquisition Guidebook
Chapter 4, Section 4.4

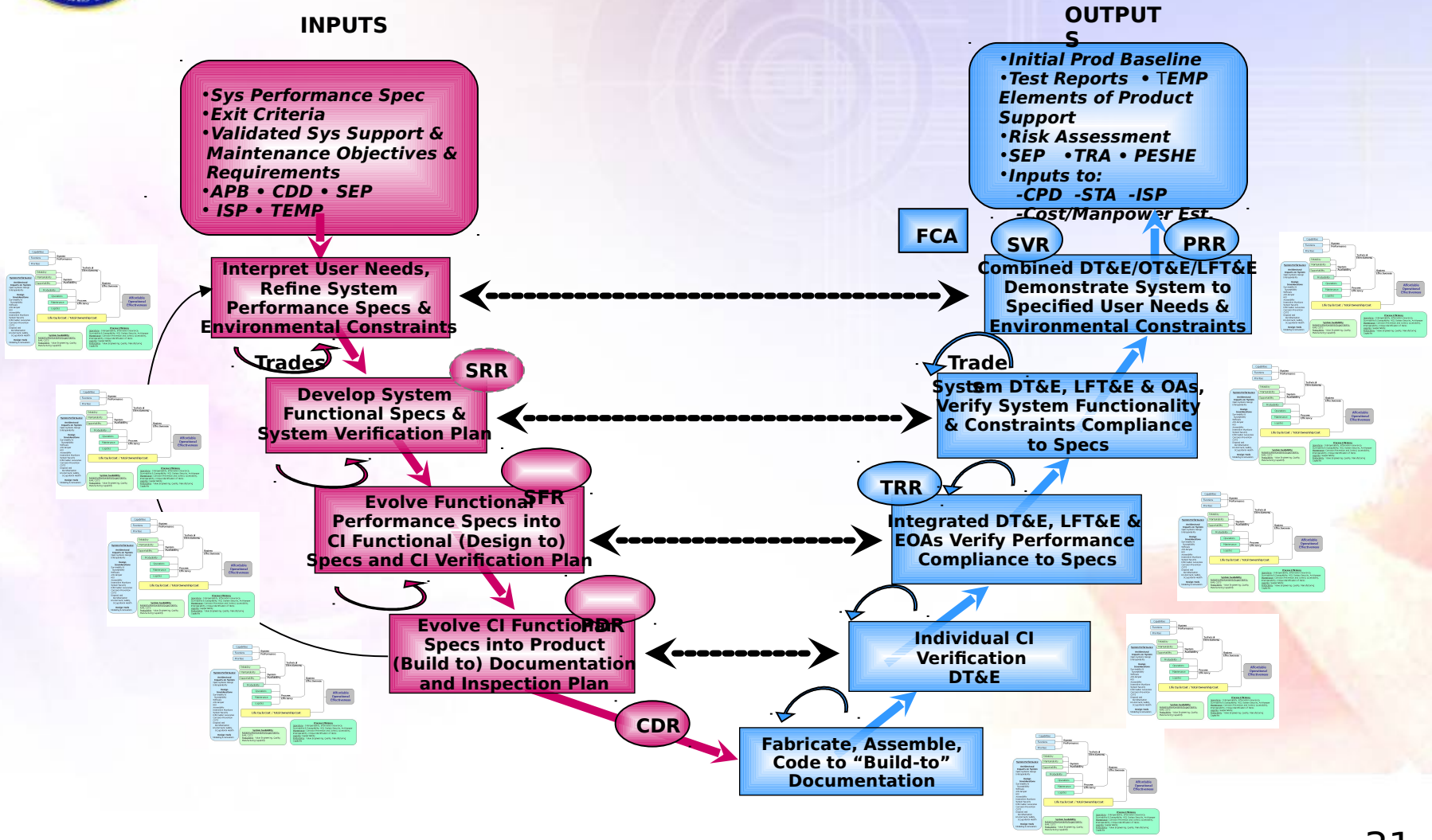
- SE must manage all requirements as an integrated set of design constra
  - KPPs
  - Statutory
  - Regulatory
  - Derived performance requirements
    - Constraints
    - Usage, duty cycle, mission profiles
- Decomposition and allocation must address entire set at each level of recursion
- Integrated set of requirements and associated stakeholders are a primary driver for program staffing (non-trivial and a major source of program risk)



Important Design Considerations "The Fishbone"



SE Must Manage All Requirements Choices in All Phases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SE Execution: Key SE Tools and Techniques
Defense Acquisition Guidebook
Chapter 4, Section 4.5

- **Systems Engineering Plan**: the who, what, when, where, why, and how
- Integrated Master Plan and Integrated Master Schedule
- Value engineering
- Technical performance measurement
- Trade studies
- Modeling and simulation by acquisition phase
- General knowledge tools: case studies, best practices, lessons learned

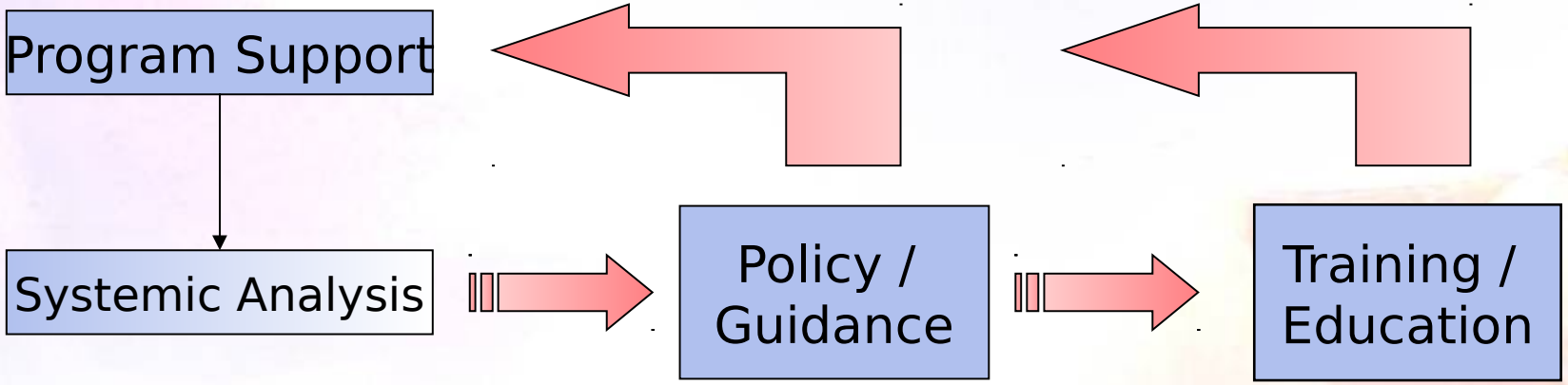
The SEP is the fundamental document fo technical planning and coordination

SE Education & Training

- DAU (DAWIA) courses under review, with plan to address broader E&T community (e.g., undergraduate and graduate courses)
  - Courses for decision makers (i.e., PMs, PEOs)
  - Core, certification courses before assignment specific
  - Career fields with large populations (viz., SPRDE)
  - Courses mandated for all Corps members (e.g., ACQ)
  - Prioritized, focused continuous learning courses (e.g., R&M, Technical Reviews, System Safety, SEP Preparation)
- Courseware review
  - First tier: ACQ, PMT 2XX/4XX, SAM 301, SYS, TST 301
  - Second tier: LOG, other PMT, other SAM, other TST, and selected BCF, CON, PQM

Assessment and Support

- Common Methodology
  - Assessment
  - IOT&E Readiness
  - Non-Advocacy



Summary

- Our ultimate goal is to help our programs and ensure mission success through revitalization of Systems Engineering
- Early and persistent SE applied to programs
- Event-driven technical reviews with expert peer participation

Systems Engineering for Miss

Backup

Systems Engineering Plan Preparation Guide

SEP Preparation Guide (Version 0.90) Outline

- Program description, technical status, and approach for updating the SEP
- SE applied and tailored to life cycle phases
  - System capabilities, requirements, and associated design considerations to be addressed
  - Technical organizational integration necessary
  - SE process selected and rationale
  - Technical baseline implementation and control and technical reviews planned
  - SEP linkage with other programmatic management efforts, such as acquisition strategy, risk management, earned value management, and contract management

SEP Contents Should Answer Series of Key Questions

- What are the technical issues?
- Who has responsibility and authority for managing the technical issues?
- What processes and tools will be used to address the technical issues?
- How will that process be managed and controlled?
- How is that technical effort linked to the overall management of the program?

What are the technical issues?

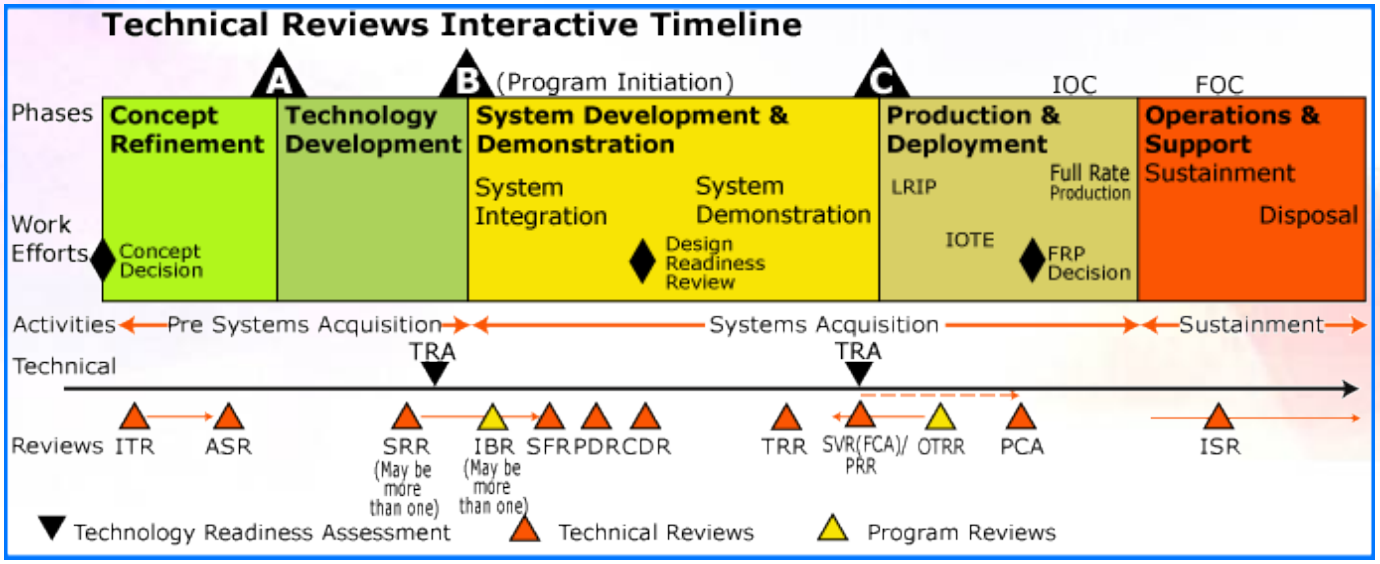
- Capability required and operational concept(s), referencing the appropriate JCIDS documents
- Key Performance Parameters (KPPs) and the rationale and basis for the KPPs
- Certification requirements
- Design considerations

Who has responsibility and authority for managing the technical issues?

- The overall organization of the systems engineering effort, including delineation of authorities, responsibilities, and integration across the government and contractor boundaries from prime contractor down to the lowest level supplier
- The authorities and role of the chief or lead systems engineer and systems engineering teams
- The staffing levels, training, and experience needed to execute the required systems engineering effort
- How the systems engineering structure is organized to provide technical management guidance across the government, prime contractor, subcontractors, and suppliers
- How technical authority will be implemented on the program to address the full spectrum of program requirements
- For family-of-systems and system-of-systems efforts, how the program-level systems engineering efforts are integrated with higher-level systems engineering authorities

What processes and tools will be used to address the technical issues?

Broad in scope and as comprehensive as the program's maturity allows, describing the top-level SE process application for the system's upcoming lifecycle phase



Approach for Trades

- Implementation and approach for trade studies:
  - Who is responsible for making trade-off decisions and at what level in the organization does that decision maker reside
  - What studies have been and will be conducted, who did or will conduct them, how they were or are to be conducted to include a discussion of trades as part of a family-of-systems or system-of-systems solution
  - Approach for progressing through the typical systems engineering steps: requirements analysis, decomposition, allocation, and analysis
  - Summary of prior trade studies and how they have steered the technical and programmatic changes to the program

How will that process be managed and controlled?

- Technical management and baseline control:
  - Who has the responsibility
  - How specifications and baselines will be managed and controlled
  - Which specification documents, identified by name, require development and which currently exist as legacy requirements and specifications

How will that process be managed and controlled?

- Technical reviews approach and strategy:
  - Technical review membership composition, including method for nominating and approving chairperson and membership
  - Roles and responsibilities of those involved
  - Procedures used in conducting reviews
  - Number of technical reviews planned and to what WBS-level
  - Entry and exit criteria for each review
  - Timing of each review
  - How technical reviews are used to manage the technical effort

How is that technical effort linked to the overall management of the program?

- Relationship and feedback mechanisms between the SE technical and key program management processes:
  - Acquisition strategy
  - Risk management
  - Earned value management
  - Contract management

What are the SEP coordination and approval mechanics?

- For ACAT ID or IAM:
  - SEP forwarded by CAE to MDA NLT 30 days before DAB or subsequent program initiation if PM needs OSD-approved document before the decision date
  - DS/SE/Assessments & Support Program Support Team lead:
    - Coordinates inside DS: SE, SMI, and SA, as appropriate for the program
    - Forwards to appropriate OIPT leader for approval
- For non-ACAT ID or IAM, SEP approved by component MDA or designated SEP approval authority